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(54) SPHEROIDAL CAST-IRON ALLOY OF INCREASED WEAR RESISTANCE

(71) We, GOETZEWERKE FRIEDRICH GOETZE A.G., a Body Corporate organised under the laws of the Federal Republic of Germany, of Bürgemeister-Schmidt-Strasse 17, 5673 Burscheid, Germany, do hereby declare the invention and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention concerns a cast-iron alloy having increased wear resistance, containing spheroidal graphite precipitates and having a carbon content in the limits of 2.5—4.5 per cent by weight, a silicon content in the limits of 1.5—4.5 per cent by weight and a sulphur content below 0.1 per cent by weight.

Mechanically highly-stressed machine parts, such as for example piston rings for internal combustion engines, besides having a definite minimum strength and toughness, must in addition, being frictionally-stressed machine parts, also have high wear resistance. Cast-iron alloys with spheroidal graphite precipitates of the usual composition possess good strength and toughness, so that for example piston rings made of this material do not fracture and are very suitable for use. The wear resistance of these materials, however, is very low, so that the running surfaces and flanks have to be protected additionally by coatings, this being done by chromium electroplating, a process which, for example, considerably increased the cost of manufacturing the piston rings.

The deficient wear resistance of cast-iron materials having spheroidal graphite precipitates of the usual composition is to be attributed to the absence of a steadite net as supporting structure in the matrix of the material. All attempts to optimise the phosphorus content in such a way that sufficient phosphorus was added for a definite steadite content to be present but which had no harmful influence on the strength, have failed because the steadite phase, even in very small amount, has a very deleterious influence. This is probably to be attributed to the fact that this phase cannot be made to crystallise in such a fine form uniformly distributed in the matrix of the material.

In accordance with the present invention there is provided a wear-resistant spheroidal-graphite cast iron alloy having the following composition:—

	per cent by weight
Carbon	2.5 —4.5
Silicon	1.5 —4.5
Sulphur below	0.1
Manganese	0.5 —1.7
Phosphorus	0.06—0.5
Chromium	0.2 —0.8
Vanadium	0.1 —2.5
Nickel	0.2 —0.8
Copper	0.2 —1.8
Titanium	0.1 —0.8
Tungsten	0.2 —2.0
Tin	0.05—1.0
Magnesium	0.02—0.5
Molybdenum	0.2 —2.0
Niobium	0.2 —2.0
Remainder	iron

With this composition, phases are produced in the structure which act like steadite for wear resistance but also have a very small spherical formation which has no more detrimental effect on the strength than the spheroids themselves.

The alloy can be produced by innoculation of the melt with ferrosilicon in conventional manner followed by addition of magnesium in elementary or alloyed form. This results in the presence of almost the desired number and form of spheroids in the cast alloy. The phosphorus which can surprisingly be in an amount of up to 0.5 per cent by weight, separates out in phosphorus-containing phases which scarcely have any detrimental effect on the strength.

It has furthermore been found that for refining the individual micro structural constituents, the elements antimony, boron, zirconium and bismuth or also the rare-earth metals may be added, but the sum of these elements must altogether be not more than 0.5 per cent by weight.

It has also been found that by heat treatment, such as for example by annealing above 700°C, followed by quenching and subsequent tempering at temperatures which may be between 200 and 700°C, further improvements can be obtained with regard strength and above all wear resistance.

The alloys according to the invention have a bainitic to martensic matrix structure. The graphite precipitates are spheroidal and the wear-resistant carbide precipitates are punctiform to spherical and form small crystals. The hardness of these alloys lies between HB 250 and HB 500 kg/cm². Tensile strengths, bending strengths, elastic modulus and wear resistance in the cast piston rings are so good that coating of the running surface with wear-resistant materials is unnecessary.

The cast-iron alloy according to the invention is represented in the following example:—

The cast-iron melt contains as alloying constituents:

3.26 per cent by weight of carbon
2.48 per cent by weight of silicon
1.29 per cent by weight of manganese
0.12 per cent by weight of phosphorus
0.04 per cent by weight of sulphur
0.63 per cent by weight of chromium
0.23 per cent by weight of vanadium
0.54 per cent by weight of nickel
1.16 per cent by weight of copper
0.5 per cent by weight of titanium
0.62 per cent by weight of tungsten
0.14 per cent by weight of tin
0.42 per cent by weight of molybdenum
0.64 per cent by weight of niobium

After inoculation with ferrosilicon, the spheroidal graphite precipitates are produced by the addition of magnesium in an amount of 0.4 per cent by weight referred to the total quantity, using a suitable device for this purpose. Then, by means of the sand mould method, piston rings are made therefrom with the dimensions 120 mm. external diameter, width 5 mm. and thickness 3 mm. They are then annealed above 700°C, air-quenched and tempered at 550°C.

The piston rings thus made have a Brinell hardness of between 394 and 438 kg/mm², and an elastic modulus of 16,340—17,880 kg/mm².

In test runs, the piston ring flanks showed a wear resistance 1½ to 2 times greater than hitherto used normal spheroidal cast-iron alloys. The unprotected running surfaces also showed in test runs an excellent wear resistance.

Figures 1 to 3 show photomicrographs of the cast iron according to the example.

Photomicrograph 1, magnification × 100, shows the spheroidal graphite precipitates.

Photomicrograph 2, magnification × 500, shows in addition to the dark spheroidal graphite precipitates, precipitates of carbides and mixed carbides as small grey crystals.

Photomicrograph 3, etched with HNO_3, magnification × 500, shows the bainitic-martensitic structure. The white crystals are again carbides or mixed carbides, while the large grey areas are formed by graphite.

WHAT WE CLAIM IS:—

1. A wear-resistant spheroidal-graphite cast-iron alloy having the following composition:—

	per cent by weight
Carbon	2.5 —4.5
Silicon	1.5 —4.5
Sulphur below	0.1
Manganese	0.5 —1.7
Phosphorus	0.06—0.5
Chromium	0.2 —0.8
Vanadium	0.1 —2.5
Nickel	0.2 —0.8
Copper	0.2 —1.8
Titanium	0.1 —0.8
Tungsten	0.2 —2.0
Tin	0.05—1.0
Magnesium	0.02—0.5
Molybdenum	0.2 —2.0
Niobium	0.2 —2.0
Remainder	iron

2. An alloy as claimed in claim 1 modified by the addition of up to 0.5 per cent by weight in total of an element or elements selected from antimony, boron, zirconium, bismuth and the rare-earth metals.

3. A process of manufacture of the alloy of claim 1 or 2 in which the melt is innoculated with ferrosilicon and afterwards with mag-

nesium in an amount of 0.4 per cent by weight.

4. An alloy as claimed in claim 1 or 2 which has been heat treated by annealing above 700°C, quenching and then tempering between 200°C. and 700°C.

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1500766 COMPLETE SPECIFICATION

1 SHEET This drawing is a reproduction of the Original on a reduced scale

FIG. 1

FIG. 2

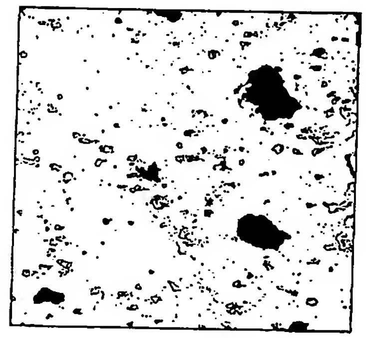

FIG. 3